International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 4, Aug 2019, 919-926

AN EXPERIMENTAL INVESTIGATION AND PROCESS PARAMETERS OPTIMIZATION OF FRICTION STIR WELDED DISSIMILAR ALLOYS

M. YADI REDDY[1] & K. RAJANIKANTH[2]

[1]*Assistant Professor, Department of Mechanical Engineering, Mahatma Gandhi Institute of Technology, Gandipet, Hyderabad, Telengana, India*

[2]*Assistant Professor, Department of Mechanical Engineering, CMR Technical Campus, Hyderabad, Telengana, India*

ABSTRACT

In this present study, FSW is joining the two dissimilar aluminum alloy sheets (AA6063 and AA5052) to examine on the hardness. The experimental method Taguchi L9 orthogonal is implemented to create the amount of welding tests. Using the wire cut EDM, the conventional ASME hardness skeleton is obtained. The sheets are efficiently joined together and the sample sheets are tested at room temperature using a Rockwell hardness tester to fine-tune the welded specimen's hardness. Analysis of ANOVA testing is conducted in order to obtain the most suitable (optimum) range of selected parameters and their results on hardness welded joints. The outcome indicates that the welding speed is 620rpm, the feed is 30 mm / min, and the tilt angle 1 are the important parameters of the method to join these different joints.

KEYWORDS: AA6063 and AA5052, Welding Speed, Feed, Tilt Angle, Taguchi L9 Orthogonal Array & ANOVA

Received: May 25, 2019; **Accepted**: Jun 15, 2019; **Published**: Jul 13, 2019; **Paper Id**.: IJMPERDAUG201993

Original Article

INTRODUCTION

The demand of the contemporary production industry is the metal and alloys with a mixture of light weight and elevated strength. Last five decades, aluminum and its alloys have been shown to be a satisfactory alternative to ferrous metals in latest years. Consolidating such light basic amalgams with ordinary combination welding strategies has dependably been a test for technologists as it includes hardening issues, for example, cracks, shrinking and segregation of alloys and so forth [1]. The rise of solid state welding methods, for example, erosion mix welding has escaped the complexities of joining and is typically performed at much diminished temperatures than combination joining strategies. Although conventional fusion welding techniques can be used to join aluminum alloys, they show a lacuna of inter-metallic forming layers that render the weld crack vulnerable. Alternatively, a solid state welding method such as friction stir welding (FSW) promotes easy welding of aluminum alloys and produces outstanding power and quality [2]. The FSW welding process is a different type of welding process and requires no metal filler or shielding gases. In several sectors, the FSW finds its business applications, such as aviation, marine and automotive industry [3, 4, 5,6].

Friction stir welding (FSW) is a solid-state joining method using a non-consumable tool to weld two facing metals (or) alloys without melting the fabric of the workpiece. Heat is produced by friction between the rotating tool and the material of the workpiece, resulting in a softened region close to the FSW instrument. While the tool is passed along the joint line, it intermingles the two parts of metal mechanically and forges the warm and loosened

metal by the physical pressure applied by the tool, much like joining clay or dough. A rotating tool with different shape of pin with a prosecuted probe is driven into a joint between two locked parent metals until the surface of the parent metals are touched by the shoulder, which has a wider diameter than the pin. The probe is significantly shorter than the necessary weld depth, with the shoulder of the tool driving over the work surface [7,8,9].

The tool pin profile and process parameters are plays important role in welding strength of the materials. The impact on welding qualities of some of the significant parameters such as welding speed, feed, tilt angle was explored. Therefore, in this examination, an attempt was developed to comprehend the impact of friction stir welded joints ' hardness characteristics from process parameters. The L9 orthogonal array is used to identify the different process parameters and the method of analyzing and ANOVA can be used to investigate or optimize the outcomes acquired. The Taguchi method is often used to found optimum permutations of process parameters to achieve maximum hardness [10,11, 12,13].

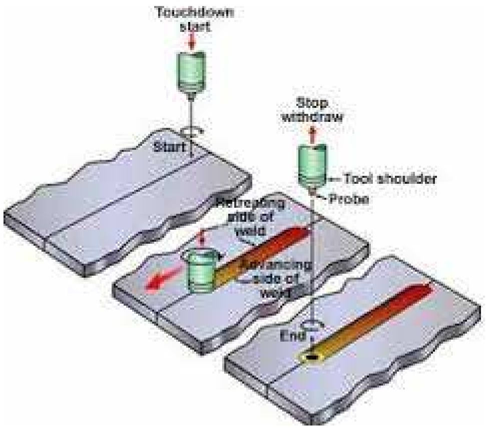

Figure 1: FSW Process

EXPERIMENTAL PROCEDURE

The dissimilar alloys AA6063 and AA5052 are preferred for the investigations and their mechanical characteristics and chemical composition are listed in the Table1 and 2. The two dissimilar alloys are appropriately fixed and welded by the FSW in fixtures. The friction stir welding arrangements is shown in the figure 1. The plate is made of rectangular samples (100mm x 60mm x 8mm) for longitudinal joining with a FSW process. Using the welding tool, the components are welded and distinct kinds of tool geometry profile are used. The profiles of the tools are rectangular, square, hexagonal, threaded, etc. and are made of carbon steel that is hardened. In this analysis, the hexagonal pin profile is selected for joining the dissimilar alloys. The experimental method of Taguchi L9 is selected to construct the quantities of welding examinations. Using ANOVA, the accurate range of system parameters and their property are analyzed on the tensile strength of the weld joints. In Taguchi method, greater is better selected to obtain the most hardness. Using an electrical-discharge cutting machine, the welded joints are cut perpendicular to the welding route for hardness test. Table 3 illustrates the corresponding process parameters to weld the dissimilar alloy specimen.

Table 1: Chemical Alliances of 6063

Components	Al	Mg	Cr	Cu	Fe	Ti	Mn	Zn	Si
Wt.%	97.64	0.44-0.91	0-0.11	0.09	0.34	0-0.11	0.11	0-0.11	0.2-0.7

Table 2: Chemical Combinaison of 5052

Components	Al	Mg	Cr	Cu	Fe	Zn	Si	Others
Wt.%	98.46	0.11	0.15-0.37	0.12	0.41	0.09	0.24	0.16

Hardness Test

Hardness is a measure of the resistance of either mechanical indentation or abrasion to localized plastic deformation. Some materials (such as metals) are more difficult than others (such as plastics). Macroscopic hardness is usually defined by powerful intermolecular bonds, but the behavior of solid metals under force is complicated; therefore, distinct hardness measurements exist: scratch hardness, hardness of indentation, and hardness of rebound. Hardness depends on elastic rigidity, plasticity, elongation, hardness, strength, viscoelasticity, and viscosity.

In this analysis, Rockwell Hardness Test is used to identify the hardness of the welded specimen. For each test, either a diamond cone or a steel ball indenter is subjected to a small load located on the surface of the welded sheet to create a zero reference place. Next, for a defined quantity of moment, a significant load is applied, leaving the small load applied upon discharge. Because of the significant load, the Rockwell hardness amount is the distinction in depth between the zero reference place and the indent. The selection of indenter depends on the specimen features. The Hardness Test uses the force values that are smaller and bigger than the Narcissistic Rockwell, but both tests give three distinct load alternatives. The Rockwell hardness testing machine is shown in Figure 2. Table 3 mentions the range of process parameters of the nine samples.

RESULTS AND DISCUSSIONS

For each experiment, the welded specimen's hardness results are noted and registered in Table 4.

Taguchi Parametric Optimization

The Taguchi method is used to find optimum combinations of process parameters to achieve maximum hardness. This method is used to discover desired result based on experiment design. Using this technique, system design and parametric design are efficiently accomplished. By Taguchi-based design of experiment, optimizing any issue can be readily solved [13].

Figure 2: Rockwell Hardness Test Machine

Table 3: Range of Process Parameters

S. No	Welding Speed (rpm)	Feed (mm/min)	Tilt Angle (mm/min)
1	900	40	1
2	900	30	1.5
3	620	30	1
4	700	40	1.5
5	900	20	2
6	700	20	1
7	620	40	2
8	620	20	1.5
9	700	30	2

ANOVA Table Analysis for Hardness

The experiments are applied on the idea of an orthogonal array that reduces the variability of experiments. Higher amount of hardness is regarded in this experiment. ANOVA analysis for hardness and influence of process parameters are shown in the Table 5 and Table 6. The delta value for welding speed is large in Table 5. It implies, the welding speed shows more effect on hardness. Table 6 confirms that the P value is 0.075, it showing that, the welding peed is more effect in hardness than that of the feed and tilt angle.

Table 4: Result of Hardness

S. No	Welding Speed (rpm)	Feed (mm/min)	Tilt angle (mm/min)	Applied Load	Hardness
1	900	40	1	100	61.33
2	900	30	1.5	100	61
3	620	30	1	100	70
4	700	40	1.5	100	65.33
5	900	20	2	100	68.67
6	700	20	1	100	67.33
7	620	40	2	100	69
8	620	20	1.5	100	63.67
9	700	30	2	100	62.33

Table 5: ANOVA Analysis Result for Hardness

Level	Speed of Welding ((rpm)	Feed (mm/min)	Tilt Angle (mm/min)
1	61.98	69.24	62.33
2	61.87	64.42	65.06
3	71.78	67.96	66.69
Delta	2.859	1.524	1.59
Rank	1	2	3

Table 6: Influence of Welding Speed, Feed and tilt Angle on Hardness

Source	DF	Adj. SS	Adj. MS	F-value	P-Value
Welding Speed	2	21.9	10.6	10.32	0.075
Feed	2	4.93	2.22	1.99	0.35
Tilt angle	2	4.26	2.23	1.97	0.33
Error	2	2.01	1.03		
Total	8	32.55			

S=2.924, R-sq=83.14 %, R-sq (adj)=83.4 %

Contour Plot Analysis for Hardness

Using the contour plot, discover the effect on the hardness of two distinct process parameters. The contour plot analysis for welding vs. feed is provided in Figure 3. At a higher welding speed and feed value, the greater quantity of hardness is achieved.

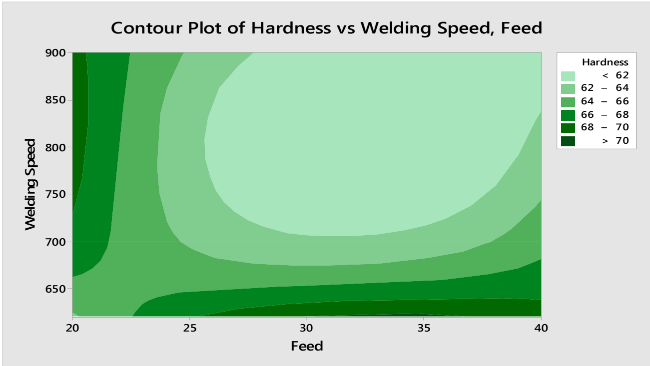

Figure 3: Hardness vs Welding Speed, Feed

The contour plot assessment for welding plot versus tilt angle can be seen in Figure 4. At lower value of welding speed and higher value of tilt angle the greater quantity of hardness is reached.

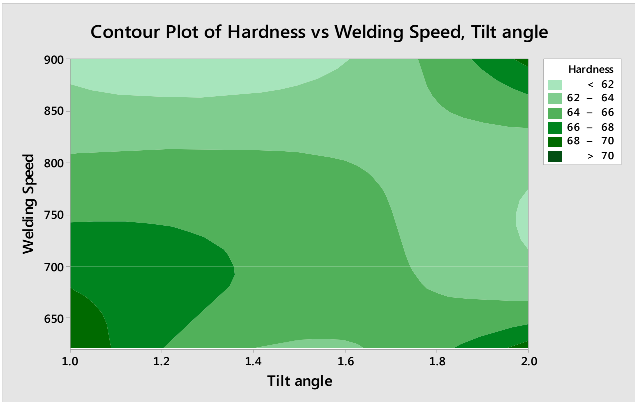

Figure 4: Hardness vs Welding Speed, Tilt Angle

The contour plot study for tilt angle versus feed is offered in Figure 5. At medium value of feed and high value of tilt angle a is achieved the higher quantity of hardness.

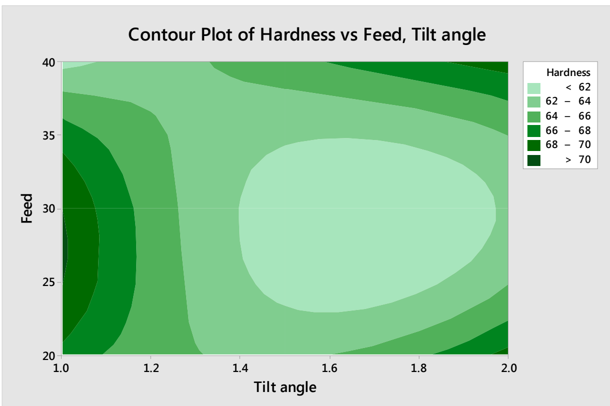

Figure 5: Hardness vs Feed, Tilt Angle

CONCLUSIONS

In this present study, FSW is joining the two dissimilar aluminum alloy sheets. To create the amount of welding tests, the experimental method Taguchi L9 orthogonal is implemented. Using the wirecut EDM, the conventional ASME hardness skeleton is obtained. The sheets are joined effectively and the specimen sheets are tested at room temperature using a Rockwell hardness testing machine to fine the hardness of the welded specimen. Analysis of ANOVA testing is performed to achieve the most appropriate (optimum) variety of chosen parameters and their outcomes on welded joints with hardness. The result shows that the welding speed is 620rpm, feed is 30 mm / min and tilt angle 1 are the influential process parameters to join these dissimilar joints.

REFERENCES

1. *Goyal, A. and Garg, R. K. 2018. Establishing Mathematical Relationships to Study Tensile Behavior of Friction Stir Welded AA5086-H32 Aluminium Alloy Joints, Silicon, 11(1), pp. 51-65.*

2. *Yuvanarasimman, P. and Malayalamurthi, R. 2018. Studies on Fractures of Friction Stir Welded Al Matrix SiC-B4C Reinforced Metal Composites" Silicon, 10(4), pp. 1375–1383.*

3. *Park, S. H. C., Sato, Y. S., Kokawa, H., Okamoto, K., Hirani, S. and Inagaki, M. 2009. Boride Formation Induced by pcBN Tool Wear in Friction-Stir-Welded Stainless Steels" Metallurgical and Materials Transactions A, 40(3), pp.625-636.*

4. *Xue, P., Xiao, B. L. and Ma, Z. Y. 2014. Achieving ultrafine grained structure in a pure nickel by friction stir processing with additional cooling, Material Decision, 56, pp.848–8451.*

5. *Dursun, T. andSoutis, C. 2014. Recent developments in advanced aircraft aluminium alloys, Material Decision, 56, pp.862–871.*

6. *Shunmugasundaram, M. Praveenkumar, A. and Maneiah, D. 2019. An experimental analysis and process Parameter optimization on friction stir welded dissimilar alloys" International Journal of Mechanical and Production Engineering Research and Development, 9(2), pp.407-414.*

7. *Cicek, V. and Ozdemir, M. 2013. Characterization Studies of Aqueous Immersion Solutions of Novel Environmentally Friendly Organometallic Corrosion Inhibitors used to Cure Aluminum 2024, 6061, and 7075 Alloys Substrates in Corrosive Media", International Journal of General Engineering and Technology, 2(2), pp.1-16.*

8. *Su, J. Q., Nelson, T. W., Mishra, R. and Mahoney, M. 2003. Microstructural investigation of friction stir welded 7050-T651aluminium" ActaMaterialia, 51(3), pp.713–729.*

9. *Cho, J. H., Boyce, D. E. and Dawson, P. R. 2005. Modeling strain hardening and texture evolution in friction stir welding of stainless steel", Materials Science and Engineering A, 398 (1), pp.146–163.*

10. *Yunus, M. and Alsoufi, M. S. 2015. A statistical analysis of joint strength of dissimilar aluminium alloys formed by friction stir welding using Taguchi design approach, ANOVA for the optimization of process parameters" International Journal of Research in Engineering and Technology, 3(7), pp.63-70.*

11. *Shunmugasundaram, M. and Maneiah, D. 2018. Wastage minimization and manufacturing cost reduction in raw edge cogged belts by lean manufacturing method, International Journal of Mechanical Engineering and Technology, 9 (7), pp.678-686.*

12. *Kumar, A., Prasad, M., & Mishra, K. P. (2013). Comparative study of effect of different parameters on performance and emission of biomass cook stoves. International Journal of Research in Engineering & Technology, 1(3), 121-126.*

13. *Praveen Kumar, A. and ShunmugaSundaram, M. 2018. An axial crushing characteristics of hybrid kenaf/glass fabric wrapped aluminium capped tubes under static loading, International Journal of Mechanical and Production Engineering Research and Development, 8 (6), pp.201-206.*
14. *Shunmugasundaram, M. and Anbumalar, V. 2016. Design of cellular manufacturing system by using new similarity coefficient algorithm to reduce total traveling time, Asian Journal of Information Technology, 15(10), pp. 1539-1546.*